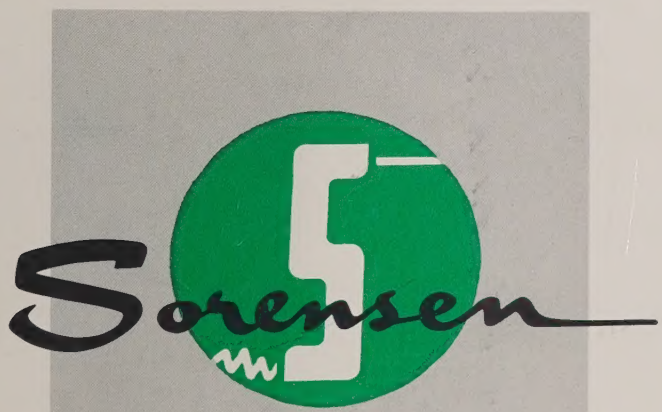
instruction manual

MODEL FRLD 750

VOLTAGE REGULATOR



SORENSEN
A Unit of Raytheon
Richards Avenue, South Norwalk, Connecticut

MP MASTER
MA25460

GENERAL INFORMATION

PLEASE READ THIS MANUAL. We think it will help you to obtain the maximum performance from your new Sorensen instrument.

SHIPPING DAMAGE

Sometimes instruments are damaged in transit. We strongly suggest that you inspect and test your instrument as soon as you receive it. If the instrument is damaged or if it fails to operate properly, you should ask the carrier to inspect the shipment. The carrier's claim agent will prepare a report of damage which you should send to us. We will then tell you how to have the instrument repaired or replaced.

SERVICE INFORMATION

If you have any questions about the operation, repair, or servicing of a Sorensen instrument, please contact our local representatives. (A list of representatives is included with this manual.) If it is more convenient you may contact us directly at the Service Department, Sorensen, Richards Avenue, South Norwalk, Connecticut.

IMPORTANT

BE SURE TO INCLUDE THE MODEL & SERIAL NUMBER IN ALL CORRESPONDENCE CONCERNING THIS INSTRUMENT. WITHOUT THIS INFORMATION WE MAY NOT BE ABLE TO GIVE YOU PROMPT AND ACCURATE SERVICE.

RETURNS TO THE FACTORY

Should you decide to return an instrument to us for repair, please contact us for authorization to make shipment. We have a number of local service facilities in the United States and Canada which are equipped and staffed to provide you with fast, efficient service. For this reason, we reserve the right to refuse unauthorized shipments to our plant.

WARRANTY

This instrument is warranted by Sorensen/Unit of Raytheon, to be free from defects in material and workmanship. Our obligation under the warranty is limited to servicing the instrument and replacing defective parts* when the instrument is returned to the factory with transportation charges prepaid. No other warranties may be implied. The period of warranty is one year after the delivery of the instrument to the original purchaser. Defects caused by improper operating conditions, accidents, misuse, negligence, and the alteration or removal of the nameplate, will void the warranty.

*With the exception of tubes and fuses.

MODEL FRLD 750

VOLTAGE REGULATOR

TABLE OF CONTENTS

	Page
I. General Information	(Inside Cover)
II. Specifications	2
III. Installation & Operation	4
IV. Principle of Operation	6
V. Maintenance & Repair	9

SORENSEN/A UNIT OF RAYTHEON CO., Richards Avenue, So. Norwalk, Connecticut

A14-2151B
2/63

II. SPECIFICATIONS

The Model FRLD750 is an AC Regulator with dual range output capacity. It features extremely fast recovery time, high ratio line transient reduction, low harmonic distortion and no phase shift from input to output.

OUTPUT POWER RANGE		750VA	1200VA
INPUT	Voltage	Range 105-125VAC	Range 110-120VAC
	Frequency	60 Cycles	
	Phase	Single Phase	
	Current	11 Amps	16.5 Amps
	Harmonic Distortion	10% Max.	5% Max.
OUTPUT	Voltage Range	110 - 120 VAC	112.5 - 117.5 VAC
	Power Factor	Unity to 0.7 lagging	
REGULATION ACCURACY	Typical 2.5% Input Distortion	±0.5% Line and Load Combined	
	2.5% - 10% Input Distortion	± 0.5% for Load ± 0.5% for Line	
DISTORTION (Typical 2% Line)		0.35%	0.35%
EFFICIENCY		64%	73.5%
RECOVERY TIME		Less than 1 cycle (0.02 Sec.)	
LINE TRANSIENT ATTENUATION		8:1 Reduction	
AMBIENT TEMPERATURE		15°C (59°F) to 35°C (95°F)	
DIMENSIONS	Cabinet	19" wide, 12-3/4" High, 15-7/8" Deep	
	Rack	Height 11-1/2"	
WEIGHT (Net)		85 Lbs.	
INPUT CONNECTIONS		3 Wire Line Cord	
OUTPUT CONNECTIONS		Terminal Board and Dual Receptacle	
PROTECTIVE DEVICES		Input and Output Fuses	
VOLTMETER (Standard Equipment)		Rectifier Type RMS, 0-130V Scale	

SPECIAL NOTES

Regulation Accuracy

When the input power is from a typical commercial line (distortion not exceeding 2. 5%) this instrument has a regulation accuracy of ±0. 5% against any combination of line and load changes within the input specification band, and output load rating.

Where conditions of high input distortion are present (distortion range from 2. 5% to a maximum of 10. 0%) the regulation accuracy is defined as ±0. 5% against line changes from 105 to 125 VAC (750VA Range) or 110-120 VAC (1200VA Range), at a fixed load from zero to full load. Under these conditions load regulation is defined as ±0. 5% for load variations from zero to full load at a fixed input line within the input rating (105-125 VAC-750VA Range, or 110-120, 1200VA Range).

Please note that this instrument can only tolerate a 5% maximum input distortion when operating at the 1200 VA Range, and still remain within specifications.

Recovery Time & Transient Attenuation

Input line surges (transient excursions) will be reduced by a factor of approximately 8:1, due to the instantaneous response of this instrument. The output voltage surge due to these transients will be out of the regulation band of the instrument ±. 5% of the output voltage setting for a period of less than one cycle.

Distortion Attenuation

Unlike conventional electronic voltage regulators which add to an input line distortion, this instrument will reduce input harmonic distortion by a factor of 8:1, with a minimum output harmonic distortion of 0. 35% always present. For example, an input distortion of 8% will appear as an output distortion of 1. 0%.

Ambient Temperature Range

If operation above 35 C (95 F) is attempted, the life of various components may be reduced. In some cases, operation at reduced loads is possible at higher ambient. This is at the discretion and responsibility of the user.

Time Delay Relays

When the input power is first turned on, a time delay relay circuit will place the load across the input power. After approximately 30 seconds, the time delay relay will transfer the load to the regulated output voltage. This is to allow sufficient time for the tube filaments to warm up.

III. INSTALLATION AND OPERATION

Rack Mounting or Bench Top Operation

This instrument when originally purchased may be supplied self-contained for bench top operation, or equipped for mounting in a standard 19" relay rack. In the event it is later desired to rack mount a self-contained unit or vice-versa, this may be done without difficulty. The user should contact our local representative or the Sorensen Service Department for the necessary parts and instructions.

Input Connections

Caution: Care must be taken in applying power to this unit.
Since one side of the input and output are common to one another, this common must be connected to the common or neutral side of the incoming line through the line cord. This may be done as follows:

1. If three prong outlets are available the line cord on the unit can be plugged directly into the line. The third prong grounds the chassis to power system ground.
2. If three prong outlets are not available, a polarized adapter must be used. The larger prong of the adapter must connect to the common or neutral side of the line.

   In addition, the grounding wire of the adapter must be connected to an earth ground such as pipe or conduit.

   Note: Non polarized adapters should not be used with this instrument.

Output Connections

The output of this instrument is available at the Terminal Board located at the rear of the instrument, and at the dual outlet receptacle also located on the rear chassis.

Air Circulation

Natural convection cooling is employed by this instrument. The installation must be such that free air circulation is available through the top and bottom of the cabinet. On self-contained units the feet elevate the instrument 1" to provide bottom air access. In rack installations, a similar provision should be made.

Controls

All controls for the operation of this instrument are located on the front panel with the exception of the output range switch which is located on the rear panel.

ON-OFF SWITCH: This switch turns the power on. When the power is first turned on, the output voltage will remain the same as the input voltage (load across input) until the time delay relays close after approximately 30 seconds.

OUTPUT VOLTAGE ADJUSTMENT: This potentiometer adjusts the output voltage from 110-120 volts. Additional swing may be available. However, above this range, specifications are not guaranteed.

RANGE SWITCH: This switch, located on the rear panel, selects the output range desired, either 750 or 1200VA.

CAUTION: DO NOT CHANGE RANGE SWITCH POSITION WHILE INSTRUMENT IS OPERATING.

PILOT LAMP: Indicates when the input power is on.

VOLTMETER: RMS type, indicates output voltage setting.

Protective Devices

This instrument has two fuses, as protective devices, both located on the rear panel.

INPUT FUSE (F1): This fuse is a 10 amp, 3AB, type and protects the DC Supply and other internal components from shorts. If this fuse blows, the instrument will shut itself off, but there will remain the unregulated line voltage at the output terminals.

OUTPUT FUSE (F2): This fuse is a 15 amp, 3AG type, and protects the instrument from overloads. If this fuse blows there will be no output voltage, however the instrument will remain on.

To Commence Operations

1. Set the VA Range Switch (rear panel) to the desired maximum power output. Be sure to follow the specifications, for the VA range selected. (Do not operate this switch while the unit is on.)

2. Plug the line cord into a 115 volt, three wire, outlet.

3. Turn "on" the "On-Off switch" at the left of the front panel. This will permit the pilot lamp to show power on and the tube filaments to receive power.

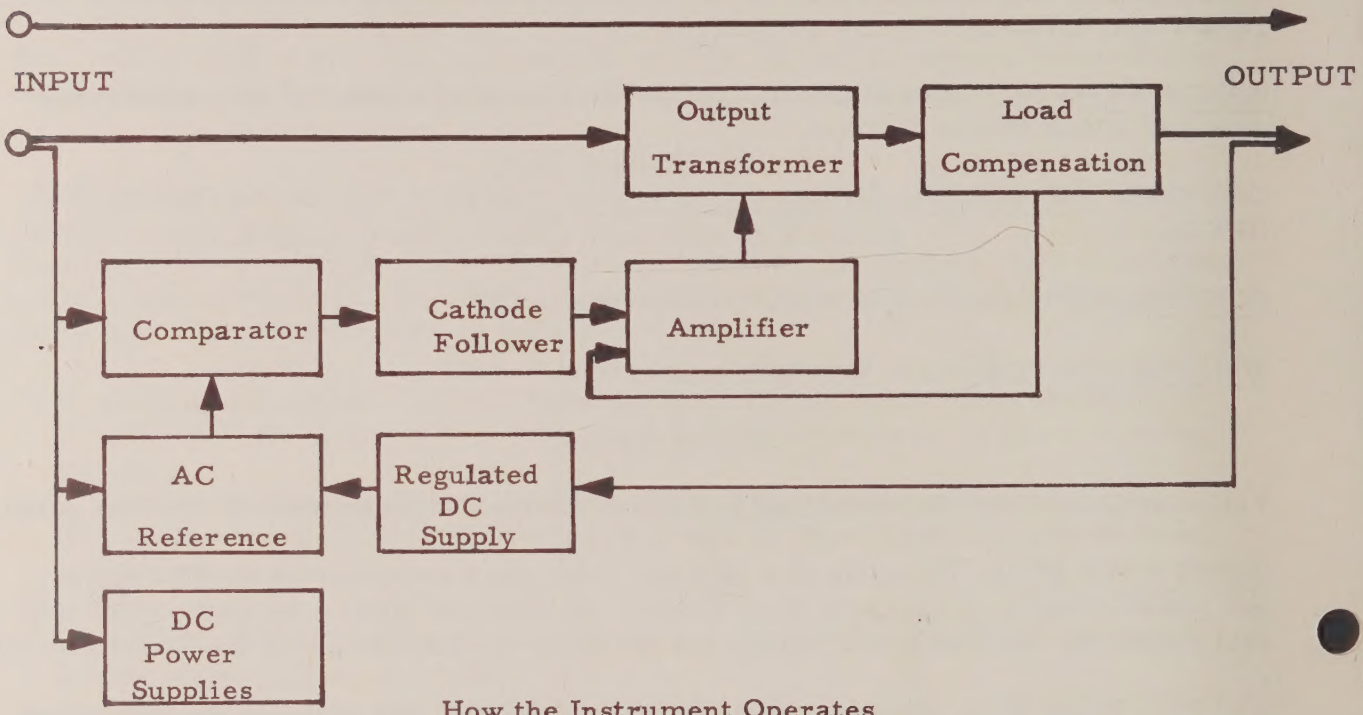
4. Approximately 30 seconds after the previous step has been carried out, the regulated output voltage will be available (action of the time delay relay circuit). Please note the description of this circuit on page 3, Specifications Special Notes.

5. Set the "Output Adjustment Potentiometer (front panel) to the desired output voltage.

6. To turn the instrument off, turn the "on-off switch" (front panel) to the Off position.

IV. PRINCIPLE OF OPERATION

The operation of the FRLD 750 Voltage Regulator can best be understood by referring to the schematic of your instrument and to the block diagram below.



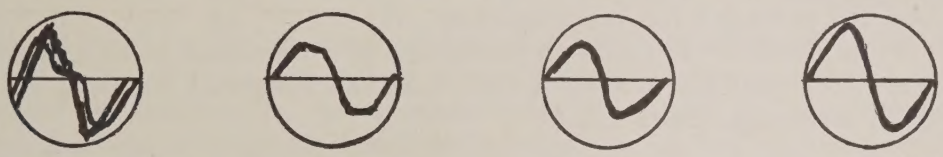
How the Instrument Operates

The Model FRLD750 provides regulation and reduced input distortion, simultaneously, in the following manner:

1. The input voltage is compared to a fixed AC voltage reference signal.
2. The resulting difference is amplified by the power amplifier and added in series with the input. This "difference" signal is composed of a waveform of all harmonic (distortion) present in the input line, plus some fundamental voltage necessary for regulation.
3. The "fundamental" voltage is added either in phase or out of phase with the input, depending upon a negative or positive variation in the input voltage.
4. A null point is chosen at the center of the range at which the signal is pure distortion. The distortion (harmonic content) is always subtracted from the input voltage.
5. Load regulation is achieved by means of feedback through the driver transformer and the power amplifier.

CIRCUIT DESCRIPTION

1. AC Reference Circuit: The AC Reference Circuit provides a fixed, distortion free AC voltage. This is accomplished by taking a portion of the input voltage and changing it to a pure AC signal. The circuit consists of (1) a phasing network to adjust the signal 180° out of phase with the input line, (2) a limiter network which clips the incoming wave form to a fixed level, (3) a filter circuit which eliminates all harmonics, and (4) an amplifier stage to obtain the proper amplitude. For clarification the functions of the different sections of this circuit are shown below by typical oscilloscope waveform.



Input Voltage (Limiter) (Filter) (Amplifier)

2. Comparison (Mixer) Circuit: The comparison or Mixer Circuit compares the input voltage with the signal received from the AC Reference Circuit. The two signals are fed out of phase to the grid of V6 to produce the error signal. This circuit consists of tubes V6 & 7 and their related RC networks. For clarification, the waveforms below show the various networks of this circuit as the error signal is produced.

Input Voltage & AC Ref. Signal

V6 Input (A) V6 Output (B) V6 Output

Note: Difference signal (A) shows the signal for distortion correction only, while difference signal (B) shows the output signal (approaching a sine wave) for distortion and regulation correction both. This regulation correction will be due to input line variations; although load variations will cause a similar signal to be picked up by the amplifier.

3. Amplifier & Output Transformer: The amplifier in this regulator is a Class B Audio Amplifier, possessing a high degree of negative feedback to improve distortion, stability, and frequency response. Its main components are the driver transformer T2, pre-amplifying tubes V8 & 9, the cathode followers V10 & 11, and the power section V12-V15 connected in push-pull. The purpose of the amplifier is to bring the "difference" (error) signal to the proper power level to achieve voltage regulation and distortion reduction.

The secondary of the output transformer is connected in series and 180° out of phase with the input line. The action of this transformer either "bucks or boosts" the input line to achieve regulation. Be being 180° out of phase with the input, the amplified "difference" signal which is fed into this transformer, is always subtracted from the input, thus attenuating its distortion.

4. Load Compensation Circuit: As previously stated, load compensation is achieved by means of a feedback through the driver transformer and the power amplifier. When a variation in the load occurs the load compensating circuit consisting of voltage step up (compensating transformer) T4, capacitor C25, and a special resistor, R66, (cupron wire which is adjusted in test for optimum compensation) feed a voltage into the driver transformer similar to that fed for line variations, thus achieving regulation.

5. DC Power Supplies: This section rectifies a portion of the input voltage to provide four DC voltages for the amplifier, (1) 1500V, (2) 325V, (3) 395V, and (4) a Bias Voltage-45V. It consists basically of a rectifier input and filament transformer, T1, rectifiers V1-3 & CR1, and the required filtering circuits of Chokes L1-3, and capacitors C 1-5.

6. Regulated DC Power Supply: This section rectifies a portion of the output voltage to provide a regulated DC power source for the AC Reference and comparison circuits. It consists of a rectifier input transformer, T5, the rectifier tube, V16, the VR tubes V17 & 18, and filter capacitor C26.

7. Time Delay Relay Circuit: A relay circuit consisting of relays K1 & 2 is provided to protect the circuits when power is first turned on. The time delay relay, K2, operates the power relay K1, after 30 seconds have elapsed. This permits the tube filaments time to warm up. Relay K1 switches the load from the input line to the regulated output voltage.

8. Long Time Stability Circuit: A feedback circuit consisting of vacuum tube V19 and diode rectifier CR3 is used to provide long time stability and reduce the temperature coefficient of the instrument.

V. MAINTENANCE AND REPAIR

Maintenance

During normal life this instrument requires no maintenance other than the care afforded similar electronic equipment. Periodic cleaning to remove excessive dust is recommended, care being taken not to damage components by excessive air blasts or rough handling.

Spare Parts

All components used in this instrument are of a good commercial grade and can be expected to give you a reasonably long period of trouble free service. As the age of your instrument increases, some components are likely to deteriorate; we therefore suggest that you note those items asterisked on the Replacement Parts List which we recommend be kept on hand.

In the event it becomes necessary to replace any part, we strongly suggest that the replacement part be of the same value as the original. Substitute parts should not be used unless we assure you that the substitute will not impair the performance of your instrument.

Repair

CAUTION: DANGEROUS VOLTAGES EXIST IN THIS INSTRUMENT, INCLUDING 1500 VOLTS ON THE PLATE CAPS OF THE 811A TUBES. BEFORE TOUCHING ANY INTERNAL PART, MAKE SURE THAT THE INPUT LINE CORD IS DISCONNECTED.

IF ANY SERVICING IS MADE TO THE PRINTED CIRCUIT BOARD USE A LOW WATTAGE IRON TO CHANGE COMPONENTS. EXCESSIVE HEAT MAY DESTROY THE PRINTED BOARD.

Typical circuit voltages are indicated on the schematic drawing included with this manual. All voltage measurements should be taken with a 20,000 ohms per voltmeter. Grid voltages should be measured with an electronic type voltmeter.

Trouble Shooting Chart

Symptom	Possible Causes & Procedure
No Output Voltage	Pilot lamp not lit but meter reads, check F1
	Pilot lamp on, but no filament voltage - check the voltage on T1
	Filament power available but no output-check F2, V16, voltages on T5, and check for continuity of F2, R66, K2 & Output.
Output Voltage Range Off Center	Center Potentiometer R22 (front panel) using an ohmmeter, then adjust R21 for 115V output

Symptom	Possible Causes & Procedure
High Distortion	Check specifications pages 2 and 3
	If output voltage reads high or low, remove K2 and V7, and center R22 on the front panel. Then adjust R9 for null from point J (located on printed board) to ground with a VTVM
Poor Load Regulation	Readjust R66 - If output drops for load use more wire, (cupron) if output increases with load, use less wire.
Poor Line Regulation	V6 defective, replace or check on tube checker (see special tube replacement notes) Page 11
High Output Voltage	Check for continuity of resistor divider to input to V6
Low Output Voltage	Check voltage range - R22
	Check signal between point (AY) located on printed board and chassis ground with a VTVM. Should read between 6 & 15 volts; If not: 1. If reads no voltage - check V4 & 5 2. Check grid V5 to read 1/2 volt 3. Check pin #7, V4 to read 10 volts approx. 4. Check T1, pins 7 & 25, should read 800 VAC, if not check T1 primary
	If point AY checks out correctly, then check DC voltages as follows: 1. Ground to junction R25 & C26B - 250V 2. Ground to terminal 2, L1 = 1100-1500V 3. Ground to junction to R3 & C3 = 325V 4. Ground to plates V10 & 11 = 395V 5. Ground to C5(-) = 45V 6. Check all components per schematic

Disassembly Instructions

In the event disassembly of the instrument is required for repair, it should be done in the following manner:

1. Remove the top, bottom and rear panels by removing the (4) machine screws holding each panel.
2. Remove the front panel by removing the (4) machine screws, being most careful not to damage components or pulling the cable.
3. Disconnect the inter-connecting cable from the chassis by the Jones Locking plug.
4. Loosen the eight (8) locking screws, four (4) from each end bell or rack mounting panel, and loosen the end bells from the front chassis. The front chassis may now be lifted from the end bells by the slots provided in the chassis.
5. The rear chassis may now be separated from the end bells or rack mounting end plates in a similar manner.
6. Re-assembly of the instrument should be made following the above procedure in reverse order.

TUBE REPLACEMENT *

Normally, when replacing tubes, no adjustment is required. However, there may be an occasion when distortion or the output range is slightly affected.

DISTORTION: Distortion is somewhat dependent on the characteristic of tube V5. V5 may have to be selected, in order, to meet the distortion specifications. If one or more of tubes V10 to V15 are replaced, unbalance currents in the output tubes may occur. This unbalance current can damage one of the output tubes and can also increase the distortion level. To balance the output tubes (V12, 13, 14 and 15, proceed as follows):

1. Insert a DC MA meter into the plate circuit of V12 and V15.
2. Connect unit to a 115 VAC source.
3. Adjust resistor R53 for an equal reading for V12 and V15. (Meter should read between 5 and 15 MA).

INSUFFICIENT OUTPUT RANGE:
The following procedure should be followed to reset the output range.

1. Remove V19 from its socket.
2. Connect unit to 115VAC source.
3. Adjust R21 until output reads 125V.
4. Replace V19 and recenter, output pot R22 by adjusting pot R75.

* We recommend that vacuum tubes V12 to V15 (Type 811A) be replaced every six months, for optimum performance of this instrument.

NOTES

MP MASTER
MA25460